Dissertation on

POST OPERATIVE PULMONARY COMPLICATIONS IN PATIENTS UNDERGOING THORACIC AND UPPER ABDOMINAL SURGERIES AND TO EVALUATE THE ROLE OF SPIROMETRY AND OTHER PARAMETERS IN PREDICTING POST OPERATIVE PULMONARY COMPLICATIONS. – A Follow Up Study

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Certificate

This is to certify that the dissertation **"POST OPERATIVE PULMONARY COMPLICATIONS IN PATIENTS UNDERGOING THORACIC AND ABDOMINAL SURGERIES AND THE ROLE OF SPIROMETRY AND OTHER PARAMETERS IN PREDICTING POST OPERATIVE PULMONARY COMPLICATION – A Follow up study"** is the bonafide work of **Dr. M. Saravanan** in partial fulfillment for M.D.BRANCH-XVII (T.B. & RESPIRATORY DISEASES) EXAMINATION of the Tamilnadu Dr. M.G.R.University to be held in March 2009. The period of study was from January 2008 to August 2008.

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DECLARATION

I, **Dr.M.Saravanan,** declare that dissertation titled **"POST OPERATIVE PULMONARY COMPLICATIONS IN PATIENTS UNDERGOING THORACIC AND ABDOMINAL SURGERIES AND THE ROLE OF SPIROMETRY AND OTHER PARAMETERS PREDICTING POST OPERATIVE PULMONARY COMPLICATION – A Follow up study"** is a bonafide work done by me at Institute of Thoracic Medicine, Chetput & Department of Thoracic Medicine, Madras Medical College & Govt.General Hospital, Chennai-3 under the guidance of my professor **Dr.N.Meenakshi M.D.(T.B.&C.D).**

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CONTENTS

INTRODUCTION

Pulmonary complications are important causes of postoperative morbidity and mortality (1). Post operative pulmonary complications such as pneumonia, atelectasis, bronchitis, pleural effusion, aspiration and bronchospasm account for increased morbidity, mortality and length of hospital stay for a patient after surgery.

In studies conducted over the past 60 yr, reported incidence of postoperative pulmonary complications (POPC) has varied between 5-70%, the highest rates were for upper abdominal and thoracic procedures (2,3).

The need for a screen test preoperatively to identify the patients at risk has been emphasized for the past several years. In the 1960s several studies concluded that spirometric tests were more sensitive than medical history and physical examination for detecting lung diseases; patients with abnormal preoperative spirometry had a higher risk for postoperative pulmonary complications ; and patients with abnormal spirometry benefit from preoperative respiratory therapy (4,5,6). However, studies have reported that spirometric tests used alone have little clinical usefulness for detecting and preventing postoperative pulmonary complications (7,8).

This study aimed to determine the incidence of postoperative pulmonary complications after thoracic and upper abdominal surgery and the value of preoperative spirometry and other parameters to predict postoperative pulmonary complications.

AIM OF THE STUDY

To evaluate the post operative pulmonary complication (POPC) in patients undergoing thoracic and upper abdomen surgery and to evaluate the role of spirometry and other parameters in predicting post operative pulmonary complication.

DESIGN OF THE STUDY

Prospective study.

This study was examined and approved by the ethical committee of the institution.

REVIEW OF LITERATURE

Post operative pulmonary complications are as prevalent as cardiac complications and contribute equally to morbidity, mortality and length of hospital stay(1). Clinically significant pulmonary complications encountered postoperatively include atelectasis, pneumonia, bronchitis, pneumothorax, aspiration, bronchospasm and worsening of underlying chronic lung disease. However, compared with Preoperative Cardiac Risk evaluation, there have been few studies predicting pulmonary risk. There is data to suggest that postoperative pulmonary complications are predictors of long term mortality.(9)

A prescient commentary in 1910 by W. Pasteur pointed the direction to our current understanding of the etiology of postoperative pulmonary complications. He noted that "when the true history of postoperative lung complications comes to be written, active collapse of the lung, from deficiency of inspiratory power, will be found to occupy an important position among determining causes."(10)Most postoperative pulmonary complications develop as a result of changes in lung volumes that occur in response to dysfunction of muscles of respiration and other changes in chest wall mechanics. Abdominal and thoracic surgical procedures cause large reductions in vital capacity and smaller but crucial reductions in functional residual capacity (FRC), which has been recognized for decades as the single most important lung volume measurement involved in the etiology of respiratory complications.(11) Although no consistent changes occur in FRC after nonabdominal ,nonthoracic surgery, FRC decreases after lower abdominal operations by 10 to 15%, by 30% after upper abdominal operations, and by 35% after thoracotomy and lung resection(12-14). Other factors that decrease FRC include the supine position, obesity, the presence of ascites, the development of peritonitis, and general anesthesia.

The other important element in the etiology of postoperative respiratory complications is the closing volume (CV), which is the lung volume at which the flow from the dependent parts of the lungs stops during expiration because of airway closure. Factors that promote an increase in CV include advanced age, tobacco use, fluid overload, bronchospasm, and the presence of airway secretions.

Under normal circumstances, FRC is about 50%and CV is about 30% of total lung capacity. When FRC is reduced or CV is increased, portions of the lung are subject to premature airway closure and atelectasis. This causes ventilation-perfusion mismatch resulting in hypoxemia and promotes the trapping of secretions resulting in pneumonitis, all of which may combine to cause respiratory insufficiency.

Thoracotomy and Lung Resection

The incidence of postoperative pulmonary complications after thoracotomy and lung resection is about 30% and is related not only to the removal of lung tissue but is also caused by alterations in chest wall mechanics due to the thoracotomy itself (15-17). All Spirometric measurements fall precipitously immediately postoperatively and do not return toward normal until 6 to 8 weeks postoperatively (18).

Knowledge about the utility of preoperative assessment of the lung resection candidate was first developed in the 1950s and further refinement has taken place since then .

Preoperative Tests for Assessing Pulmonary

Risk Prior to Major Lung Resection

Test Value Range for Low-risk Patients

FEV1% > 60 %

Dlco% > 60 %

PpoFEV1 > 800 mL

PpoFEV1% > 40 %

PpoDlco% > 40 %

$\dot{V}o2max$ during exercise > 15 mL/kg/min

Early methods of evaluating risk included the measurement of bellows function of the lungs such as maximum voluntary ventilation and FRC (19). The latter continues to be important for this purpose. Air flow parameters that are useful include FEV1 and forced expiratory flow rate in the middle 50% of the forced expiratory flow curve (20,21).

Because raw spirometric values are relatively inaccurate for surgical candidates at the far ends of the body mass spectrum, further refinement of these measurements has included expressing them as a percentage of predicted based on patient age, sex,and height(19,21,22). The calculation of postoperative predicted values for both spirometric raw numbers and percentage of predicted values has further increased the accuracy of spirometry as a preoperative tool for evaluating pulmonary risk preoperatively (22-24). This calculation is usually performed by estimating the number of functional lung segments that will remain postoperatively. Quantitative ventilation-perfusion scans used to assess regional lung function have aided considerably in the calculation of predicted postoperative spirometric function in patients who are considered borderline candidates for operation based on standard techniques (25, 26).

In addition to these standard methods, other measures of gas exchange and oxygen consumption have also proved useful in the preoperative assessment of risk. These include clinical assessments such as the 6-min walk distance and stair climbing effort and laboratory measures of exercise capacity such as maximum oxygen consumption during exercise(V˙ o2max)(27,28). All have shown some promise in the prediction of postoperative pulmonary complications and, in some settings, postoperative mortality. Measurement of gas exchange capacity using diffusing capacity of the lung for carbon monoxide (Dlco) has proved to be an independent and useful means of estimating operative risk for patients undergoing major lung resection. Preoperative raw values or values expressed as a percent of predicted (Dlco%)as well as calculated postoperative values expressed as a percent of predicted function have all been shown to be useful, although the best value to use is the calculated postoperative Dlco expressed as a percent of predicted (ppoDlco%)(23,29,30). In patients preselected as adequate candidates for lung resection on the basis of spirometry, the risk of pulmonary complications is best defined by patient age and ppoDlco%(30). A direct comparison between the use of Dlco% and V˙ o2max revealed that Dlco% was a better predictor of pulmonary complications after lung resection (17).

There have been important advances in the selection and postoperative care of the lung resection patient since the time most of the data noted previously were derived. Postoperative analgesia with epidural catheters or patient-controlled delivery devices has substantially reduced surgical pain. Vigorous pulmonary toilet exercises are used more routinely and frequently. Experience in lung volume reduction surgery and lung transplantation has increased our knowledge of how to treat critically ill patients with end-stage emphysema. There have also been changes in the way in which lung resection operations are performed. The use of muscle-sparing thoracotomy reduces post thoracotomy pain, retains shoulder girdle muscle strength, and may permit improved spirometric function in the early postoperative period compared with a standard lateral thoracotomy (15, 31). Further improvements such as these may be evident with additional experience using thoracoscopic lung resection techniques. At the present time, the risk of postoperative pulmonary complications in the candidate for lung resection should be evaluated with age and performance status during the initial history and physical examination. Based on the extent of planned lung resection, postoperative predicted spirometry and diffusing capacity are calculated (Table 1). For high risk patients, an additional assessment of V˙ o2maxmay be useful. Conclusions about the utility of muscle-sparing and thoracoscopic approaches await further data.

Cardiac Surgery

The incidence of pulmonary complications after cardiac surgical procedures is high and includes pneumonitis, bronchospasm, or lobar collapse in 40%, prolonged mechanical ventilation in 5 to 10%, and generalized respiratory dysfunction in most patients who undergo cardiopulmonary bypass (32).The etiology of pulmonary complications in patients who undergo cardiac surgery has some factors that are similar to those that have been identified for pulmonary complications that develop after lung resection, specifically alterations in chest wall mechanics due to the incision. FRC is decreased by nearly 20% at the time of hospital discharge but is normal at 3 months after the operation.

Interestingly, whether an internal mammary artery is used for bypass grafting has an important impact on respiratory function postoperatively. Increasing age and the use of an internal mammary artery graft have significant and independent negative impacts on spirometric values postoperatively (33). In contrast to lung resection patients, however, the prediction of pulmonary complications after cardiac surgery is not aided by preoperative measurement of lung volumes and flows (32).

Two unique factors contribute to the development of pulmonary complications after cardiac surgery .The first of these is the use of topical slush to protect the myocardium, which results in phrenic nerve paralysis in. 30% of patients compared with an incidence of , 5% in patients in whom no topical slush is used. The use of slush is also associated with an incidence of left lower lobe collapse of. 80%compared with only 32% in patients in whom no slush is used (34).

The other unique factor that is associated with the development of pulmonary complications is the use of cardiopulmonary bypass. Within 24 h of surgery, there is a reduction in arterial oxygen tension of 30%, an increase in the alveolar-arterial oxygen gradient of 150% and an increase in the pulmonary shunt fraction from a baseline of 3% to 19% .These changes only partially resolve by the end of the first postoperative week and eventually return to baseline values after 6 weeks. The only predictor of this complication is a preoperative abnormality of the alveolar-arterial oxygen gradient. The presumed etiology of this profound dysfunction is the activation of a multitude of inflammatory mediators in addition to the factors mentioned above.

The overall preoperative assessment of pulmonary risk in a patient who is to undergo cardiac surgery is based more on the planned operation and less on the patient’s preoperative status than for any other preoperative assessment. Issues of critical importance other than patient age and performance status are the choice of conduit if the patient is having coronary artery bypass grafting, the technique used for myocardial protection, and possibly the duration of cardiopulmonary bypass. Whether the minimally invasive approaches to bypass grafting and valve repair or replacement will reduce the incidence of postoperative pulmonary complications is as yet unknown.

Esophagectomy

Postoperative pulmonary complications occur in25 to 50% of patients after esophagectomy (35).These complications arise from a number of factors ,including the type of incision used, the extent of mediastinal dissection, the development of a recurrent laryngeal nerve injury that may impair coughing efficiency postoperatively, and the presence of an intrathoracic reconstructive organ or pleural effusion that may directly impair ventilation in the early postoperative period.

The risk of pulmonary complications after esophagectomy is predicted on the basis of a number of preoperative factors, including patient age, spirometric values, diffusing capacity, performance status ,nutritional status, and a diagnosis of COPD(35). Intraoperative factors also strongly predict the likelihood of pulmonary complications. An increase in complications is associated with an increased volume of blood loss, use of the substernal rather than the posterior mediastinal route for esophageal reconstruction, and routine use of ventilatory support rather than early extubation postoperatively(35). The type of incision used to perform the resection is also a predictor of the likelihood of postoperative pulmonary complications. Use of an isolated left thoracotomy results in fewer complications than does an Ivor Lewis approach combining a right thoracotomy and laparotomy. The Ivor Lewis approach is associated with fewer complications than is a transhiatal approach, in which a laparotomy and cervical incision are performed and no thoracotomy is necessary (36). The development of pulmonary complications is associated with a sevenfold increase in the risk of operative mortality, and pulmonary complications account for 40 to 60% of operative mortality (35).

Because of the high incidence of pulmonary complications and associated operative mortality after esophagectomy, a thorough preoperative evaluation of pulmonary risk is appropriate in candidates for esophagectomy. The evaluation should include a general assessment of age, performance and nutritional status, measurement of spirometric values, and an assessment of diffusing capacity. Knowledge of the planned approach to resection and the route to be used for reconstruction will also provide useful information regarding the risk of postoperative pulmonary complications.

Abdominal Surgery

The incidence of pulmonary complications after abdominal surgery is about 30%, a frequency that is high enough to have stimulated considerable research into the etiology of this problem (37). In addition to dysfunction of abdominal wall musculature, the supine position, the development of ascites and other factors that reduce FRC postoperatively after laparotomy, abdominal surgery has the unique propensity to impair diaphragmatic function, an effect that further contributes to the reduction in FRC. Transdiaphragmatic pressure decreases by almost70% on the first postoperative day and does not return to normal until at least 1 week postoperatively (38). Adequate relief of postoperative pain does not reduce this impairment that appears to result from dysfunction of the diaphragm itself rather than from phrenic nerve or central neural sources. Upper abdominal operations are associated with substantially worse diaphragmatic function post operatively than are lower abdominal operations, and the risk of postoperative pulmonary complications is accordingly higher by a factor of 1.5(39).

The accurate preoperative prediction of pulmonary risk associated with abdominal surgery has been somewhat elusive. The use of spirometry to assess which patients are at greatest risk has enjoyed wide spread popularity, but its predictive value when used routinely is unproved. Clinical factors that have been shown to be useful in the prediction of postoperative pulmonary complications include a history of smoking, chronic bronchitis, airflow obstruction, obesity, and a prolonged preoperative hospital stay(39). The presence of colonizing bacteria in the stomach and the use of nasogastric intubation increase the specific risk of postoperative pneumonia (39). Smaller incisions and the use of laparoscopic techniques promise to reduce the incidence of pulmonary complications by preventing substantial reductions in pulmonary function postoperatively, but the data supporting these outcomes are scant at the present time.The most important predictive factors appear to be the overall condition of the patient (based on the classification of the American Society of Anesthesiologists) and patient age.

Based on available information, the preoperative evaluation of pulmonary risk in the candidate for abdominal surgery should include an assessment of patient age, general performance status, relative weight, pulmonary comorbid conditions, the planned operation, and the incision that is to be used.Spirometry is indicated in patients in whom severe pulmonary dysfunction is evident as a means to assess whether a period of pulmonary rehabilitation is indicated to improve the preoperative pulmonary condition prior to an elective operation. Post operative pulmonary complications are as prevalent as cardiac complications and contribute equally to morbidity, mortality and length of hospital stay. Clinically significant pulmonary complications encountered postoperatively include atelectasis, pneumonia, bronchitis, pneumothorax, aspiration, bronchospasm and worsening of underlying chronic lung disease. However, compared with Preoperative Cardiac Risk evaluation, there have been few studies predicting pulmonary risk. There is data to suggest that postoperative pulmonary complications are predictors of long term mortality.

Patient Related Risk Factors Associated with Postoperative Pulmonary Complications:

Age above 60 years

Chronic Obstructive Lung Disease

Cigarette Use: current and recent abstinence

Congestive Heart Failure

Comorbid Conditions: ASA class II and above

Functional Dependence: Total dependence (inability to per form Activity of daily living or ADLs) and partial dependence (requiring some assistance for ADLs)

Obstructive Sleep Apnea

ASA (American Society of Anesthesiologists) Classification:

ASA 1 - A normal healthy person

ASA II - A patient with mild systemic disease

ASA III - A patient with systemic disease that is not incapacitating

ASA IV - A patient with an incapacitating systemic disease

that is a constant threat to life

ASA V - A moribund patient who is not expected to survive

for 24 hours with or without operation

Patient Related Risk Factors Not Associated with Postoperative Pulmonary Complications:

1. Obesity
2. Impaired Sensorium
3. Diabetes
4. Stable Asthma

Patient Related Risk Factors with Inconclusive Data

1. Chronic Restrictive Lung Disease
2. HIV Infection
3. Exercise Tolerance

Patient Related Risk Factors

Age –

There has been conflicting data in the literature regarding the independent role of age and post operative pulmonary complications. Initial studies suggested an increased risk of pulmonary complications with advanced age, but in the subsequent studies, age as a predictor failed to show any statistical difference. The American College of Physicians recently performed a systematic review of the current literature using multivariate analysis to adjust for age related co morbidities and found that age > 50 years was an independent predictor of risk.

Chronic lung disease –

Chronic obstructive lung disease is the fourth leading cause of chronic morbidity and mortality in the United States. It has been well known that the severity of chronic obstructive lung disease correlates well with the risk for postoperative pulmonary complications. The best way to avoid postoperative pulmonary complications is to have the patient in his/her best physical condition prior to the surgery. This can be achieved by optimizing medications and treating their disease exacerbations aggressively.

There is no level of pulmonary function below which surgery is absolutely contraindicated, which would mean that if the benefits of the surgery are outweighing known risks, the surgery may be performed with caution. Patients presenting to the physician's office for preoperative evaluation should be specifically assessed for decreased breath sounds, prolonged expiration, rhonchi, rales or wheezing. In the presence of these clinical findings, patients' medications should be optimized and the underlying cause treated aggressively because these findings increase the risk of postoperative pulmonary complications.

Asthma –

According to the National Center for Health Statistics, 7.2 percent of the adult population in the United States has asthma. Patients who have well controlled asthma have an average risk of postoperative pulmonary complications. Corticosteroids may be used in asthmatics with wheezing, productive cough, chest tightness, or shortness of breath while on their usual therapy. Perioperative steroid use does not seem to increase the risk for postoperative pulmonary complications.

Smoking –

Patients who are current smokers have a higher incidence of postoperative pulmonary complications. Smokers have a higher incidence of postoperative ICU admissions and have a five fold increased rate of postoperative complications(40). Smokers who have more than a 20 pack year smoking history have an increased rate of postoperative complications as compared with those who have a lesser pack year history. Smokers who quit within two months of a surgical procedure have an increased risk of pulmonary complications as compared to those who have quit for longer duration or are still smoking. Smoking cessation within two months preoperatively may transiently increase the risk of postoperative pulmonary complications due to increased tracheobronchial secretions.

Obesity –

Obesity on its own does not increase the rate of postoperative pulmonary complications, and obese patients who are scheduled to undergo high risk procedures should be able to tolerate the procedure if they are otherwise healthy.

Obstructive sleep apnea –

The impact of Obstructive Sleep Apnea (OSA) is under study at this point. There are not enough studies to suggest the role of OSA on postoperative risk for a patient.

General Health Status –

Functional dependence and impaired sensorium increase the risk of postoperative pulmonary complications. Plausible reasoning is that patients are either too weak to cooperate with lung expansion therapy,have weak cough reflex, or are unable to clear out their secretions effectively.

Metabolic Factors –

Serum albumin less than 3.0 gm/dl and blood urea nitrogen greater than 30mg/dl each have been independently associated with an increased risk of postoperative pulmonary complications. *(Table 1)*

Procedure Related Risk Factors

Surgical site –

The distance of the surgical incision from the diaphragm is inversely related to the rate of postoperative pulmonary complications. Upper abdominal surgeries are thought to have increased rates of complications because of their effect on the diaphragm and the respiratory muscles. Head and neck surgeries and abdominal aortic surgeries are also associated with higher postoperative pulmonary complications.

Duration of Surgery –

Surgical procedures lasting more than three hours have been associated with a higher risk of pulmonary complications (41). It has, therefore, been suggested to consider procedures of shorter duration to minimize the risks for postoperative pulmonary complications.

Anesthesia –

A large systematic review found that there was a reduction in risk of pulmonary complications in patients receiving epidural or spinal anesthesia as compared to general anesthesia (42). Pancuronium, a long acting neuromuscular blocker, has been found to lead to higher incidence of postoperative pulmonary complications(43). Due to pancuronium’s long duration of action, it is more likely to lead to postoperative residual neuromuscular blockade, which in turn, leads towards a tendency of hypoventilation and increased postoperative pulmonary complications in patients.

Laboratory Evaluations

Complete history and physical examination are the mostimportant elements of preoperative pulmonary evaluation. Additional laboratory testing helps to confirm and risk stratify a subgroup of patients who may be thought to be at increased risk for postoperative pulmonary complications and for whom preventive measures need to be instituted prior to surgery.

Pulmonary Function Testing –

Pulmonary Function Testing (PFT) may be performed in patients with asthma or chronic obstructive pulmonary disease if their clinical evaluations fail to determine that they are at their baseline and if the patients are at their best. PFTs, on the other hand, should not be the primary reason for denying surgery, and they should not be requested routinely prior to surgery.

Arterial Blood Gas –

Preoperative Arterial Blood Gas (ABG) is only recommended in patients who are undergoing coronary bypass surgery or upper abdominal surgery with a history of tobacco use or dyspnea, and in all patients undergoing lung resection surgery.

Chest radiograph –

Routine preoperative chest radiograph has been found to add little to a good clinical evaluation and is therefore, not recommended. The need to obtain chest x-ray on patients who are older than 50 years of age, with a history of cardiopulmonary disease and undergoing high risk surgery needs to be individualized.

Exercise Testing –

There is no data to support its routine use in the evaluation of patients prior to general surgery.

Initial Preoperative Assessment

Assessment of Respiratory Function

The best assessment of respiratory function comes from a history of the patient's quality of life. It is useful to have objective measures of pulmonary function that can be used to guide anesthetic management and to have this information in a format that can be easily transmitted between members of the health care team. There are many factors that determine overall respiratory performance. It is useful to think of the respiratory function in three related but somewhat independent areas: respiratory mechanics, gas exchange, and cardiorespiratory interaction.

Respiratory Mechanics. Many tests of respiratory mechanics and volumes show correlation with postthoracotomy outcome. It is useful to express these as a percent of predicted volumes corrected for age, sex, and height (e.g., forced expiratory volume in 1 s, FEV1). Of these, the most valid single test for postthoracotomy respiratory complications is the predicted postoperative forced expiratory volume in 1 s (ppoFEV1), which is calculated as: ppoFEV1% = preoperative FEV1% × (1 - % functional lung tissue removed/100) Nakahara et al (44). Found that patients with a ppoFEV1 ›40% had no or minor post-resection respiratory complications. Major respiratory complications were only seen in the subgroup with ppoFEV1 ‹40% and patients with ppoFEV1 ‹30%

required postoperative mechanical ventilatory support. The use of epidural analgesia has decreased the incidence of complications in the high-risk group.

Lung Parenchymal Function.

Arterial blood gas data such as Pao2 ‹60 mm Hg or Paco2 ‹45 mm Hg have been used as cut-off values for pulmonary resection. Cancer resections have now been successfully done or even combined with volume reduction in patients who do not meet these criteria . The most useful test of the gas exchange capacity of the lung is the diffusing capacity for carbon monoxide (DLCO). The DLCO correlates with the total functioning surface area of alveolar-capillary interface. The DLCO can be used to calculate a post-resection (ppo) value using the same calculation as for the FEV1. A ppoDLCO ‹40% of predicted correlates with both increased respiratory and cardiac complications and is relatively independent of the FEV1 .

Cardiopulmonary Interaction.

The most important assessment of respiratory function is an assessment of the cardiopulmonary interaction. The traditional test is stair climbing . The ability to climb 3 flights or more is closely associated with decreased mortality and morbidity; ‹2 flights is associated with very high risk. Formal laboratory exercise testing with maximal oxygen consumption (V˙ o2max) is the “gold standard” for assessment of cardiopulmonary function. Climbing 5 flights of stairs approximates a V˙ o2max of

›20 mL · kg_1 · min-1 and ‹1 flight a V˙ o2max ‹10 mL · kg_1 · min-1 (45). In a high-risk group of patients (mean preoperative FEV1 = 41% of predicted), there was no perioperative mortality if the preoperativeV˙ o2max was ›15 mL · kg_1 · min-1. Alternatives to V˙ o2max include the 6-min walk test and exercise oximetry.

Ventilation Perfusion (V/Q) Scintigraphy. Prediction of post-resection pulmonary function can be further refined by assessment of the preoperative contribution

of the lung or lobe to be resected using V/Q lung scanning . If the lung region to be resected is nonfunctioning or minimally functioning, the prediction of postoperative function can be modified accordingly. This is particularly useful in pneumonectomy patients and should be considered for any patient who has a ppoFEV1 ‹40%. Other tests of pulmonary function such as split-lung function studies and flowvolume loops have not shown sufficient predictive validity for widespread universal adoption in potential lung resection patients.

Combination of Tests.

No single test of respiratory function has shown adequate validity as a sole preoperative assessment. Before surgery an estimate of respiratory function in all three areas: lung mechanics, parenchymal function, and cardiopulmonary interaction

should be made for each patient. If a patient has a ppoFEV1 ›40% it should be possible for that patient to be extubated in the operating room at the conclusion of surgery assuming the patient is alert, warm, and comfortable ("AWaC"). If the ppoFEV1 is ›30% and exercise tolerance and lung parenchymal function exceed the increased risk thresholds, then extubation in the operating room may be possible depending on the status of associated diseases. Those patients in this subgroup who do not meet the minimal criteria for cardiopulmonary and parenchymal function should be considered for staged weaning from mechanical ventilation postoperatively so that the effect of the increased oxygen consumption of spontaneous ventilation can be assessed. Patients with a ppoFEV1 20%–30% and favorable predicted cardiorespiratory and parenchymal function can be considered for early extubation if thoracic epidural analgesia if used. The validity of this approach has been confirmed by the National Emphysema Treatment Trial, which found an unacceptably high mortality for lung volume reduction surgery in patients with preoperative FEV1 and DLCO values ‹20% of predicted.

Intercurrent Medical Conditions

Age.

If a patient is 80 yr of age and has a stage Ilung cancer, their chances of survival to age 85 yr are better with the tumor resected than without. However, the rate of respiratory complications (40%) is double that expected in a younger population and the rate of cardiac complications (40%), particularly arrhythmias, triples that which should be seen in younger patients. Although the mortality from lobectomy in the elderly is acceptable, the mortality from pneumonectomy (22% in patients ›70 yr) , particularly right pneumonectomy, is excessive. Pulmonary resection in the elderly should be regarded as a highrisk procedure for cardiac complications and cardiopulmonary reserve is the most important predictor of outcome in this population .

Cardiac Disease.

Cardiac complications are the second most common cause of perioperative morbidity and mortality in the thoracic surgical population.

Ischemia.

Most pulmonary resection patients have a smoking history and already have one risk factor for coronary artery disease. Pulmonary resection surgery is an “intermediate risk” procedure in terms of perioperative cardiac ischemia. Noninvasive testing is indicated in patients with major (unstable ischemia, recent infarction, severe valvular disease, significant arrhythmia) or intermediate (stable angina, remote infarction, previous congestive failure, or diabetes) clinical predictors of myocardial risk and also in the elderly.

Arrhythmia.

Dysrhythmias, particularly atrial fibrillation, are a frequent complication of pulmonary resection surgery. Factors known to correlate with an increased incidence of arrhythmia are the amount of lung tissue resected, age, intraoperative blood loss, and intra-pericardial dissection. Prophylactic therapy with Digoxin has not been shown to prevent these arrhythmias. Diltiazem has been shown to be effective.

Renal Dysfunction.

Renal dysfunction after pulmonary resection surgery is associated with a very high incidence of mortality (19%). The factors which are associated with an elevated risk of renal impairment are history of previous renal dysfunction, diuretic therapy, pneumonectomy, postoperative infection, and transfusion.

Chronic Obstructive Pulmonary Disease.

Recent advances in the understanding of chronic obstructive pulmonary disease (COPD) that is relevant to anesthetic management include the following:

Respiratory Drive.

Many COPD patients have an elevated Paco2 at rest. To identify these patients preoperatively, all moderate-to-severe COPD patients need arterial blood gas analysis. This CO2-retention seems to be primarily related to an inability to maintain the increased work of respiration and not to an alteration of respiratory control mechanisms . The Paco2 rises in these patients when supplemental oxygen is administered because a high Fio2 causes a relative increase in alveolar dead space by the redistribution of lung perfusion and from the Haldane effect. However, supplemental oxygen must be administered to these patients postoperatively to prevent hypoxemia. The attendant rise in Paco2 should be anticipated and monitored.

Nocturnal Hypoxemia.

COPD patients desaturate more frequently and severely than normal patients during sleep . This tendency to desaturate, combined with the postoperative fall in functional residual capacity (FRC) and opioid analgesia places these patients at high risk for severe hypoxemia postoperatively during sleep.

Right Ventricular (RV) Dysfunction.

RV dysfunctionoccurs in up to 50% of COPD patients. The dysfunctional RV is poorly tolerant of sudden increases in afterload such as the change from spontaneous to controlled ventilation. Pneumonectomy candidates with a ppoFEV1 ‹40% should have transthoracic echocardiography to assess right heart function. Elevation of right heart pressures places these patients in a high-risk group.

Combined Cancer and Emphysema Surgery.

The combination of volume reduction surgery or bullectomy in addition to lung cancer surgery has been reported in emphysematous patients who previously would not have met minimal criteria for pulmonary resection because of their concurrent lung disease. Although the numbers of patients reported are small, the expected improvements in postoperative pulmonary function have been seen and the outcomes are encouraging.

This offers an extension of the standard indications for surgery in a small, well selected, group of patients. There are four treatable complications of COPD that must be sought and treated at the initial prethoracotomy assessment: atelectasis, bronchospasm, chest infection, and pulmonary edema.

Table 1. Initial Preanesthetic Assessment for Thoracic Surgery

1. All patients: assess exercise tolerance, estimate ppoFEV1%, discuss postoperative analgesia, D/C smoking

2. Patients with ppoFEV1 _ 40%: DLCO, V/Q scan, V˙ o2 max

3. Cancer patients: consider the "4 M's": mass effects, metabolic effects, metastases, medications

4. COPD patients: art, blood gas, physiotherapy, bronchodilators

5. Increased renal risk: measure creatinine and BUN

Table 2. Final Preanesthetic Assessment for Thoracic Surgery

1. Review initial assessment and test results

2. Assess difficulty of lung isolation: examine chest radiograph and CT scan

3. Assess risk of hypoxemia during one-lung ventilation:

High percentage of ventilation or perfusion to the operative lung on preoperative V/Q scan

Poor Pao2 during two-lung ventilation

Right-sided surgery

Good preoperative spirometry (FEV1 or FVC)

Postoperative Strategies to Reduce PulmonaryComplications

Lung expansion –

Various maneuvers are available to help postoperative patients expand their lungs. They include incentive spirometry, deep breathing exercises, chest physical therapy, intermittent positive pressure breathing, and continuous positive airway pressure. Deep breathing exercises or incentive spirometry should be used in patients undergoing thoracic, aortic and upper abdominal surgery who are at higher than normal risk for pulmonary complications. Deep breathing exercises have been found to reduce postoperative pulmonary complications by nearly one half. Continuous Positive Airway Pressure (CPAP) may be beneficial in patients who are less cooperative and are unable to perform regular deep breathing exercises.

Pain Control –

Patients with well controlled pain have an improved ability to take deep breaths. Epidural analgesia and intercostal nerve blocks postoperatively have been associated with reduced pulmonary complication rates by reducing postoperative pain(46). Use of opioids postoperatively for pain management should be individualized for every patient because of increased risk of respiratory depression.

Nasogastric Tube –

A Nasogastric (NG) tube used to decompress the stomach postoperatively after abdominal surgery routinely demonstrated a trend towards increased pulmonary complications. Therefore, NG tubes should not be routinely used and are only recommended in patients with nausea, vomiting, inability to tolerate oral intake or symptomatic abdominal distension.

Postoperative pulmonary complications contribute to morbidity, mortality and length of hospital stay. In 2006 the American College of Physicians published guidelines for strategies to reduce post operative pulmonary complications for patients undergoing non cardiothoracic surgery (47).

Summary of the guidelines follows:

1.The guidelines suggest that all patients undergoing noncardiothoracicsurgery should be evaluated for presence of chronic obstructive pulmonary disease, age greater than 60 years, American Society of Anesthesiologist (ASA) class II or greater, functional dependence and history of congestive heart failure.

2.The guidelines outline the procedures that predispose a patient to a higher risk of postoperative pulmonary complications. These include general anesthesia, prolonged surgery (>3hours), abdominal surgery, thoracic surgery, neurosurgery, head and neck surgery, vascular surgery, aortic aneurysm repair and emergency surgery.

3.The guidelines outline the preoperative laboratory markers that are strong predictors of postoperative pulmonary complications. They include a serum albumin level of <3.5g/dl and a blood urea nitrogen of >21g/dl.

4.The guidelines highlight methods to reduce post operative pulmonary complications in patients deemed to be high risk. It includes deep breathing exercises or incentive spirometry postoperatively and selective use of nasogastric tubes postoperatively for nausea, vomiting, inability to tolerate oral intake or symptomatic abdominal distension.

5.Preoperative spirometry and chest x-ray should not be routinely used for predicting risk for postoperative pulmonary complications. Exceptions to these guidelines include patients with chronic obstructive pulmonary disease and asthma.

6.The guidelines specifically identify procedures that should not be used in an attempt to reduce postoperative pulmonary complications. They include right heart catheterization and total parenteral nutrition or total enteral nutrition.

Kocabas et al describes in his study that POPC developed in 35% of patient who underwent upper abdominal surgery. The incidence of POPC was reported to be greater than20-25% in different studies. It seems that differences in the characteristics of patients studied and the definition of pulmonary complication affect the reported incidence of complications in various studies. Studies reported that respiratory treatment regimens provided in the preoperative and postoperative periods such as intermittent positive pressure breathing, chest physical therapy and incentive spirometry decrease the occurrence of POPC. The high incidence of POPC observed in this study may be related to the absence of respiratory therapy practice in patients studied.

This study found that POPC incidence was higher in patients with abnormal preoperative spirometry (45.2%) than in patients with normal preoperative spirometry (21.4%) (P=O.O4). In addition to this, POPC developed more frequently in patients with lower FEV1, (FEV1<1.25 1 or ~50% of predicted).

In this study, POPC developed more frequently in patients with abnormal preoperative findings- of physical examination (66.7%) than in patients with normal physical findings (13.9%) (P<O.OOl). Sensitivity and specificity of abnormal preoperative spirometry to predict POPC were lower than those of abnormal findings of physical examination (Table 7). These findings indicate that spirometry may not be an ideal screening test to predict POPC. In support of this conclusion, there were no differences between patients with and without abnormal spirometry regarding duration of

operation, duration of hospital stay after operation, ASA class and prevalence of pneumonia developed (a serious pulmonary complication). However POPC incidence was found to be higher in patients with lower preoperative FEV1, (less than 1.25 1 or less than 50% of predicted). It seems that preoperative spirometry may be beneficial to predict POPC among a specific subset of patients with severe pulmonary disease.

He concludes that POPC after elective upper abdominal surgery is still common (35%) and it is an important cause of postoperative morbidity. Multiple factors, which include abnormal preoperative spirometry, are responsible for the genesis of POPC. However, spirometry used alone has a limited benefit to predict POPC after upper abdominal surgery (48).

Fuso et al describes in his study that a low FEV1 value was the main determinant of PC after elective abdominal surgery and that a low value of PaO2 was the second more significant predictor of PC. Clinically ischaemic heart disease was the only comorbid disease with a significant predictive value.

Finally, operation for malignant tumours and ageing also predicted postoperative PC. In the group of patients with a score value in the highest quintile of the score distribution, postoperative complications were very common, with a sharp increase of the risk in comparison with patients characterized by a score value below 15.1. It is obvious that the contemporary presence of variables with a higher statistical significance, such as a low FEV1 and PaO2, determined a high score value. Thus, patients with both moderate-to-severe bronchial obstruction and hypoxaemia had a risk for PC after abdominal surgery significantly higher than patients with normal functional pattern and normal pulmonary gas exchanges. In conclusion, his results showed that a moderate-to- severe impairment of FEV1 and PaO2 were significant predictors of post operative PC after elective abdominal surgery in a cohort of patients at increased risk of complications. Taking into account age, type of operation and the presence of cardiac diseases, spirometry and arterial gas analysis could be useful as preoperative screening tests and the original score derived from the multi-variate analysis could be applied in clinical practice. However, a prospective study should be planned in order to confirm the predictive value of the respiratory functional data and to further evaluate the role of the score in assessing the actual risk of PC after abdominal surgical procedures (49).

Jensen et al showed POPCs occurred in 99.4% of his CABG surgical cohort. Atelectasis, pleural effusion, atelectasis with pleural effusion, and pneumonia were the most frequent POPCs post CABG surgery. Age >65 years, diabetes, and ASA classification >3 were found to be related to the presence of atelectasis. No significant risk factors were related to the development of pleural effusion or atelectasis with pleural effusion. Postoperative pneumonia was associated with previous myocardial infarction, ventilation >10 h, and hospital stay >5 days. History of bronchitis and COPD were related to postoperative pneumothorax; history of heart failure, COPD, and other lung diseases were related to postoperative pulmonary edema. Concluded that these findings contribute to the understanding of POPCs in post-CABG surgery patients and assist in identification of patients at risk for developing POPCs(50).

Bluman et al demonstrated that current smokers experienced significantly more postoperative pulmonary complications than past or never smokers. This finding is consistent with results from several other studies. Wellman and Smith found that the incidence of postoperative pulmonary complications following upper abdominal and thoracic surgery was doubled in cigarette smokers, and that smoking 20 cigarettes per day was associated with a fourfold increase in postoperative atelectasis. Results of univariate logistic regressions were consistent with previous studies in identifying smoking status, history of COPD, upper abdominal/thoracic surgery, and use of general anesthetic as significant predictors of pulmonary complications. Current smokers were approximately six times more likely than never smokers to develop postoperative pulmonary complications. After controlling for other predictors of complications, the risk for current smokers was four times that of never smokers. The magnitude of the effect of smoking on development of postoperative pulmonary complications in this study was similar to that found inprevious studies. Wightman reported postoperative pulmonary complications in patients undergoing abdominal surgery to be 14.8% among smokers, as compared with 6.3% among never smokers. Dales et al concluded that current cigarette smokers experienced a doubling of the complication rate when compared with nonsmokers. Another major finding of this study was that current smokers who reduced their cigarette consumption prior to surgery had nearly seven times the risk of developing a postoperative pulmonary complication compared with those who did not reduce consumption, after adjusting for potential confounders. Among those who cut down within a month of surgery, those who cut down closest to the surgery date were at the greatest risk of developing a postoperative pulmonary complication. Subjects who reduced consumption >1 month prior to surgery appeared to be at greatly increased risk of developing a postoperative pulmonary complication; however, these individuals scored significantly lower on their peak flow spirometry tests ($p=0.05$) and were more likely to have a history of pulmonary disease (p=0.04), when compared with those who reduced consumption within 1 month prior to surgery. The vast number of Americans who smoke experience high levels of morbidity and mortality. Smoking is known as the most preventable of the risk factors for mortality in the United States. Therefore, physicians and other health-care providers should counsel their patients on the importance of smoking cessation/reduction for their health and well-being and be actively involved in encouraging their patients to alter their behaviors. Estimates indicate that 70% of the population sees a physician at least one time per year and that 90% visit a physician at least once in 5 years. Physicians tend to see smokers at times when they are likely to want to quit, and the perioperative period may be a time of increased motivation for patients to alter their smoking behaviors. Physicians may be in a unique position to deliver smoking cessation messages; however, they must know the optimal time to advise their patients to reduce/stop smoking. Results from a limited number of studies have suggested that the optimal time for smoking reduction/cessation among patients who have not previously quit is between 1 and 8 weeks prior to surgery. Our results suggest that this period may need to be even longer. Additional research needs to be conducted to further clarify the appropriate time for preoperative smoking reduction to be initiated to effectively reduce risk for postoperative pulmonary complications(40).

Adel K. Ayed et al The mean age of the patients was 47.1 years (range 16-80 years), 137 (77%) patients underwent lobectomy, 23 (14%) pneumonectomy, and 15 (9%) bilobectomy. Forty-six (27%) patients developed postoperative pulmonary complications and 2 (1.1%) died within 30 days following the operation. Age 65 years (p = 0.002), the presence of comorbid cardiopulmonary disease (p = 0.001), FVC <50% (p

= 0.02), blood transfusion (p = 0.0001), and extended operation (p = 0.005) were the identified factors associated with the development of postoperative pulmonary complications, which necessitated an increased length of hospital stay. He Concluded Postoperative pulmonary complications are more likely to develop in patients with age 65 years with comorbid cardiopulmonary disease, FVC <50%, blood transfusion, and extended operation (51).

Kroenke et al The 26 patients with severe COPD had rates of cardiac, vascular, and minor pulmonary complications similar to patients with mild-moderate COPD and without COPD, but experienced higher rates of serious pulmonary complications and death. All deaths and instances of ventilatory failure in the patients with severe COPD occurred in the subset undergoing coronary artery bypass surgery. Logistic regression revealed that increased age, higher American Society of Anesthesiologists class, an abnormal chest radiograph, and perioperative bronchodilator administration were associated with higher cardiac or serious pulmonary complication rates. Spirometry was not an independent predictor of postoperative complications. He concluded that clinical variables appear better than preoperative spirometry in predicting postoperative cardiopulmonary complications. The utility of preoperative spirometry as well as the benefits of perioperative bronchodilators in patients in stable condition remain to be determined (52).

Slinger et al concluded recent advances in anesthesia and surgery have made it so that almost any patient with a resectable lung malignancy is now an operative candidate given a full understanding of the risks and after appropriate investigation. This necessitates a change in the paradigm that we use for preoperative assessment.

Understanding and stratifying the perioperative risks allows the anesthesiologist to develop a systematic focused approach to these patients, both at the time of the initial contact and immediately before induction, which can be used to guide anesthetic management (53).

Lawrence et al revealed Postoperative pulmonary complications contribute to morbidity, mortality and length of hospital stay (54). In 2006 the American College of Physicians published guidelines for strategies to reduce post operative pulmonary complications for patients undergoing non cardiothoracic surgery. A summary of the guidelines follows:

Recommendation 1: All patients undergoing noncardiothoracic surgery should be evaluated for the presence of the following significant risk factors for postoperative pulmonary complications in order to receive pre- and postoperative interventions to reduce pulmonary risk: chronic obstructive pulmonary disease, age older than 60 years, American Society of Anesthesiologists (ASA) class of II or greater, functionally dependent, and congestive heart failure. The following are not significant risk factors for postoperative pulmonary complications: obesity and mild or moderate asthma.

Recommendation 2: Patients undergoing the following procedures are at higher risk for postoperative pulmonary complications and should be evaluated for other concomitant risk factors and receive pre- and postoperative interventions to reduce pulmonary complications: prolonged surgery (_3 hours), abdominal surgery, thoracic surgery, neurosurgery, head and neck surgery, vascular surgery, aortic aneurysm repair, emergency surgery, and general anesthesia.

Recommendation 3: A low serum albumin level (_35 g/L) is a powerful marker of increased risk for postoperative pulmonary complications and should be measured in all patients who are clinically suspected of having hypoalbuminemia; measurement should be considered in patients with 1 or more risk factors for perioperative pulmonary complications.

Recommendation 4: All patients who after preoperative evaluation are found to be at higher risk for postoperative pulmonary complications should receive the following postoperative procedures in order to reduce postoperative pulmonary complications: 1) deep breathing exercises or incentive spirometry and 2) selective use of a nasogastric tube (as needed for postoperative nausea or vomiting, inability to tolerate oral intake, or symptomatic abdominal distention).

Recommendation 5: Preoperative spirometry and chest radiography should not be used routinely for predicting risk forpostoperative pulmonary complications.Preoperative pulmonary function testing or chest radiography may be appropriate in patients with a previous diagnosis of chronic obstructive pulmonary disease or asthma.

Recommendation 6: The following procedures should not be used solely for reducing postoperative pulmonary complication risk: 1) right-heart catheterization and 2) total parenteral nutrition or total enteral nutrition (for patients who are malnourished or have low serum albumin levels).

Joshi et al Large number of elderly individuals are undergoing surgery because of the advances in surgical and anesthetic techniques combined with sophisticated perioperative monitoring.Preoperative assessment is useful to identify risk factors and to recommend a management plan that minimizes the risks. Each person should be assessed individually and judgments should be based on an individual.s problem and physiological status, not on age alone. Older persons often have overlapping comorbid conditions that limit their functional capacity, recovery and increase the risk of death. Advanced age, poor functional status, impaired cognition, and limited home support are risk factors for adverse outcomes. In one study, the mortality rate for patients older than 70 years undergoing elective cholecystectomy was nearly 10 times that for younger patients. In a study of abdominal operations, the mortality rate for patients aged 80-84 years was 3%; the rate was 9% for patients aged 85-89 years and 25% for those older than 90 years. However, when age and severity of illness are directly compared, severity of illness is a much better predictor of outcome compared to age. Emergency operations are an independent predictor of adverse postoperative outcomes in elderly persons (55).

Hulzebos et al. To our knowledge, this is the first randomized clinical trial of a preoperative prophylactic tailored physical therapy intervention in patients scheduled for primary elective CABG surgery, based on artery occlusion, who are at high risk of developing PPCs. As hypothesized, preoperative physical therapy with inspiratory muscle training (IMT) in high-risk patients significantly improved inspiratory muscle function. Moreover, in patients receiving preoperative physical therapy, the incidence of PPCs was reduced by 50% compared with patients receiving usual care. Consequently, the duration of postoperative hospitalization was significantly lower in the IMT group. Postoperative pulmonary dysfunction after CABG surgery is associated with a longer duration of mechanical ventilation, difficulty weaning the patient, and prolonged hospitalization, and may be associated with higher mortality. We found that preventive physical therapy with IMT administered to patients at high risk of PPCs before CABG surgery was associated with an increase in inspiratory force and length of hospitalization. We consider this to be an important presurgical intervention that appears to be effective at reducing morbidity (56).

Saad et al describes the incidence of postoperative complications was 18.6%. Multivariate logistic regression analysis showed that the variables increasing the chances of postoperative pulmonary complications were wheezing (odds ratio, OR = 6.2), body mass index (OR = 1.15), smoking (OR = 1.04) and surgery duration (OR = 1.007). He concluded Wheezing, body mass index, smoking and surgery duration increase the chances of postoperative pulmonary complications in thoracic surgery (57).

Arozullah et al results confirm several previously described risk factors for postoperative pneumonia, including the type of surgery performed. The patient-specific risk factors were related to general health and immune status, respiratory status, neurologic status, and fluid status. These risk factors were used to develop a preoperative risk assessment model for predicting postoperative pneumonia, the postoperative pneumonia risk index (58).

Postoperative Pneumonia Risk Index

Preoperative Risk Factor	**Point Value**
Type of surgery	
Abdominal aortic aneurysm repair	15
Thoracic	14
Upper abdominal	10
Neck	8

Neurosurgery	8
Vascular	3
Age	
≥80 y	17
70–79 y	13
60–69 y	9
50–59 y	4
Functional status	
Totally dependent	10
Partially dependent	6
Weight loss. 10% in past 6 months	7
History of chronic obstructive pulmonary disease	5
General anesthesia	4
Impaired sensorium	4
History of cerebrovascular accident	4
Blood urea nitrogen level	
2.86 mmol/L (8 mg/dL)	4
7.85–10.7 mmol/L (22–30 mg/dL)	2
$10.7 mmol/L ($30 mg/dL)	3
Transfusion 4 units	3
Emergency surgery	3
Steroid use for chronic condition	3
Current smoker within 1 year	3

Alcohol intake 2 drinks/d in past 2 weeks 2

Pneumonia rates were

0.2% among those with 0 to 15 risk points,

1.2% for those with 16 to25 risk points,

4.0% for those with 26 to 40 risk points,

9.4% for those with 41 to 55 risk points,

and 15.3% for those with more than 55 risk points.

We found that patients undergoing abdominal aortic aneurysm repair; thoracic, neck, upper abdominal, or peripheral vascular surgery; or neurosurgery had an increased likelihood of developing postoperative pneumonia. Previous studies focused on the increased incidence of postoperative pulmonary complications in patients undergoing these types of surgery. Impairment of normal swallowing and respiratory clearance mechanisms may be responsible for some of the increased risk in these patients. We found several patient-specific risk factors for postoperative pneumonia related to general health and immune status. Long-term steroid use and age older than 60 years have previously been found to be risk factors for postoperative pneumonia. We discovered three additional risk factors: dependent functional status, weight loss greater than 10% of body mass in the previous 6 months, and recent alcohol use. Further studies are needed to assess the effect of interventions, such as preoperative optimization of nutritional status and perioperative physical therapy, in reducing the incidence of postoperative pneumoniaWe found two risk factors related to neurologic status: history of cerebral vascular accident with a residual deficit and impaired sensorium. Previously identified neurologic risk factors for postoperative pneumonia included impaired cognitive function

. These risk factors are often associated with a decreased ability to protect one's airway and may increase the risk for aspiration. Other risk factors related to aspiration in previous studies included the use of nasogastric tubes and H2 receptor antagonists (.In conclusion, we used a combination of risk factors to develop and validate a postoperative pneumonia risk index for predicting pneumonia after major noncardiac surgery. Many potential intraoperative and postoperative factors influence the development of postoperative pneumonia as well. Our model may be used to control for preoperative patient-specific and operation-specific risk factors in future studies of interventions designed to modify intraoperative and postoperative risk factors. The risk index may be useful for patient-mix adjustment in studies exploring hospital variation in postoperative pneumonia rates and evaluation of hospital-level interventions designed to reduce the incidence of postoperative pneumonia. The Postoperative Pneumonia Risk Index may also be useful to clinicians in estimating patient risk for postoperative pneumonia and in targeting perioperative testing and respiratory care to high-risk patients. We hope that awareness of pneumonia as a significant, potentially preventable postoperative complication will increase as a result of the clinical use of the Postoperative Pneumonia Risk Index.

To summarize various literatures has shown the POPC incidence of 5-70%. Various predisposing factors such as age, smoking, ASA, body mass index, comorbid illness, preoperative history and clinical examination, serum albumin, blood urea nitrogen, spirometry, ABG, X-Ray, type of surgery , duration of surgery, post operative physiotherapy were studied but no single parameter has emerged to predict POPC. Spirometry which has been evaluated exhaustively has shown varying results in predicting POPC. Spirometry predictiveness of POPC increases when it is used along with other parameters such as history and clinical examination, ASA, ABG, and preoperative X-Ray.

MATERIALS AND METHODS

The study was conducted in Cardiothoracic Department and Surgical Gastroenterology Department of Madras Medical College, Government General Hospital, Chennai. The study started from January 2008 to August 2008. The study population was selected from cardiothoracic and surgical gastroenterology department of GGH.

Inclusion criteria:

1. Elective thoracic surgical patient who performed spirometry in cardiothoracic department.

2. Elective upper abdominal surgical patient who performed spirometry in surgical gastroenterology department.

Exclusion criteria:

1. Patients who cannot perform spirometry.

2. Patients not willing to enroll themselves in this study.

Totally hundred and two patients were selected from CTS (58 patients) and SGE (44 patients) department who were posted for elective surgery. Patient were assessed a day before surgery and monitored for seven days after surgery.

Preoperativly all patients were assessed by

1. Body mass index
2. Smoking history.
3. Co morbid illness
4. ASA (American society of anesthesiologists) grading.
5. Signs and symptoms of respiratory system
6. X-Ray chest.

7. Pulmonary function test by Spirometry.

Patients with respiratory symptoms (cough, sputum, dyspnoea, wheezing) and abnormal findings from physical examination of the chest (orthopnoea, increase or decrease of tactile fremitus, dullness, crackles or rhonchus) were defined preoperatively as 'symptomatic patients'.

Post operatively patients were monitored for seven days by imaging and by clinical examination.

In this study, postoperative pulmonary complications were classified as

1. Pneumonia
2. Bronchitis
3. Atelectasis
4. Pleural effusion

Pneumonia (diagnosed if the patient had a fever higher than 38.5"C, purulent sputum, positive blood and/or sputum culture, leucocytosis, as well as clinical and/or radiological evidence of consolidation that was not present before surgery);

Bronchitis (diagnosed if dyspnoea, purulent sputum, wheezing, rhonchus developed in a stable patient preoperatively);

Atelectasis (diagnosed if the patient had clinical and radiologic evidence of collapse); and

Pleural effusion (diagnosed if the patient had tachypnoea, dyspnoea, signs of chest radiography and by clinical examination).

Spirometeric tests were performed by super spiro in sitting position. Spirometry was performed as per ATS guidelines (described below) for spirometry.

Forced vital capacity (FVC), FVC%, forced expiratory volume during the first second of (FEV1), FEV1%, FEV1/FVC, PEF, PEF% were recorded. Patients with abnormal spirometry were those patients with one or more abnormal spirometry values.

PERFORMANCE OF FVC MANEUVER

Check spirometer calibration

Explain test

Prepare subject

Ask about smoking, recent illness, medication use, etc.

Instruct and demonstrate test to subject

Correct posture with head elevated

Inhale completely

Position mouthpiece (open circuit)

Exhale with maximal force for at least 6 secs

Perform maneuver

Have subject assume correct posture

Attach nose clip

Inhale completely; the inhalation should be rapid but not forced

Place mouthpiece in mouth and close lips around mouthpiece

Exhale maximally as soon as lips are sealed around mouthpiece'

Repeat instructions as necessary, coaching vigorously

Repeat for a minimum of three maneuvers; no more than eight are usually required

Check test reproducibility and perform more maneuvers as necessary

ACCEPTABILITY CRITERIA

1. Free from artifacts (such as cough or glottis closure in early expiration).
2. Free from leaks.
3. Good start –extrapolated volume less than 5% of FVC or 0.15 liters (whichever is Greater)

   OR

   - Time to peak expiratory flow less than 120 milisecs.
4. Acceptable exhalation – at least 6 secs of exhalation and / or plateau in volume Curve (plateau = no detectable change in volume over 1 secs)

REPRODUCIBILITY CRITERIA

1. Three acceptable manoeuvres.
2. The two largest FVC measurements within 0.2 liters of each other.
3. The two largest FEV1 measurements within 0.2 liters of each other.

If both acceptability and reproducibility criteria are met, the test can be concluded.If Not manoeuvres should be repeated until either criteria are met or the patient is Unable to continue.A maximum of eight attempts is recommended.

In the case of results which are acceptable but not reproducible, the largest of the acceptable measurements should be reported along with the comment that reproducibility criteria were not met.

Patients with respiratory symptoms (cough, sputum, dyspnoea, wheezing) were defined preoperatively as ‘symptomatic patients’. Patients with one or more abnormal findings from physical examination of the chest (orthopnoea, increase or decrease of tactile fremitus, dullness, crackles or rhonchus) preoperatively were defined as ‘patients with abnormal findings of physical examination’.

The data of this study were analysed by the SPSSX statistical package. Student’s t-test and chi-squared test-when necessary were used for the comparison of group means and proportions respectively. A P-value of less than 0.05 was assumed as significant.

RESULTS

Data of 102 patients planned for thoracic and upper abdominal surgery (40 female and 62 male) were analyzed. Patients' characteristics are shown in Table1. 73 (71.5%) patients had abnormal preoperative spirometry, 24 patients had obstructive, and 49 had restrictive. Actual and percent of predicted values of preoperative spirometric tests of patients are shown in Table 2.fig 1-3 shows patients characteristics in pie and bar chart.

Table 1 Patients characteristics

Patient number	102
Male : Female ratio	62 : 40
Age < 50 > 50	68 34
BMI < 25 >25	76 26
Smoking Male	36 (35.29% 36(58%)
Preoperative signs and symptoms	35 (34.31%)
Preoperative spirometry Normal Obstructive Restrictive	 29 (28.43%) 24 (23.55%) 49 (48.04%)
Co morbid Diabetes Hypertension	 39 (38.23%) 16 (15.68%)

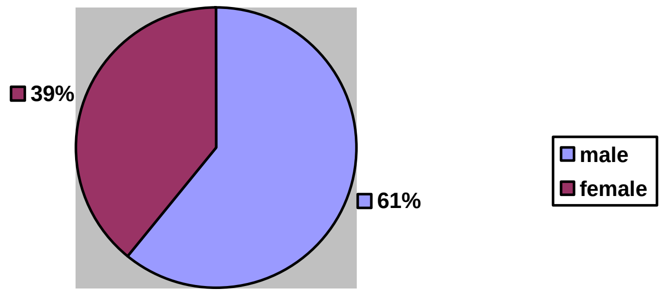

Fig 1. Male : female ratio

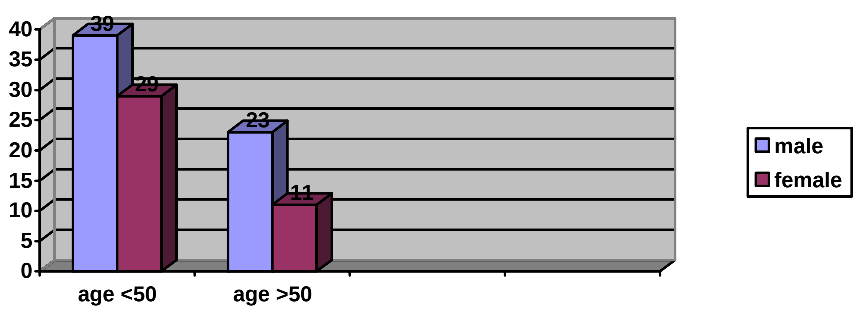

Fig 2. Age and sex distribution of patients studied

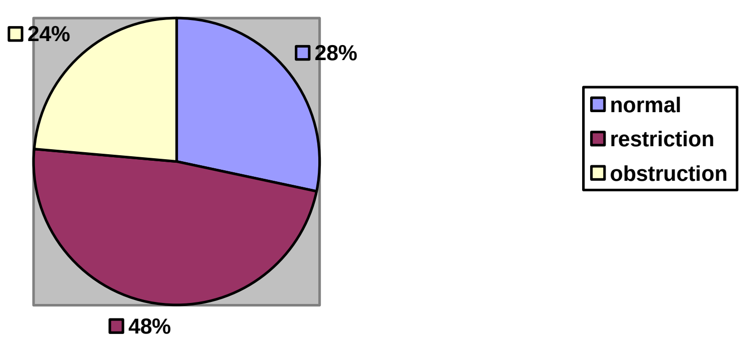

Fig 3. Spirometry interpretation

Total number of cardiothoracic and surgical gastroenterology surgery is 58 and 44 respectively. Various indications for surgeries in both departments are shown in (table-3 and table–4)**.**

Spirometry results

Table – 2 Actual and % values of preoperative spirometric test of patients with and without abnormal spirometry.

	Normal		obstructive		Restrictive	
Spirometric test	Mean	SD	Mean	SD	Mean	SD
FVC	2.85	± 0.51	2.43	±0.80	1.67	±0.49
FVC%	90.55	± 8.20	77.13	±25.33	56.55	±12.30
FEV1	2.47	±0.43	1.62	±0.51	1.56	±0.47
FEV1%	95.34	±11.59	60.21	±13.97	61.92	±14.50
FEV1/FVC	88.59	±3.58	66.83	±4.21	91.18	±5.04
PEF	5.46	±1.71	3.59	±1.49	3.83	±1.41
PEF%	75.93	±17.83	46.96	±17.27	53.67	±18.55

Table - 3 Indications for cardiothoracic surgery

Cardiac	
CABG	22
ASD	10
RHD	4
PDA	1
Lung resection	
Bronchiectasis	7
Destroyed lung	4
Tumor	2
Aspergilloma	2
Decortications	4
Thymectomy	3
Total	58

Table - 4 Indications for upper abdominal surgery

Carcinoma stomach	13
Cholecystectomy	11
Carcinoma esophagus	6
Chronic pancreatitis	4
Hydatid cyst	4
Carcinoma pancreas	3
Pseudo cyst of pancreas	3
Spleenectomy	1
Total	44

Post operative pulmonary complications were observed in 30 (29%) patient in 7 days follow up (see fig 5). POPC is 27%, 31.8%, and 35% in thoracic, abdomen and lung resection respectively see (fig 4).POPC increases with the age above 50, BMI>25, ASA > 2, smoking, diabetes, FEV1/FVC <80 and FEV1 < 1.25 lit. (See table-5).

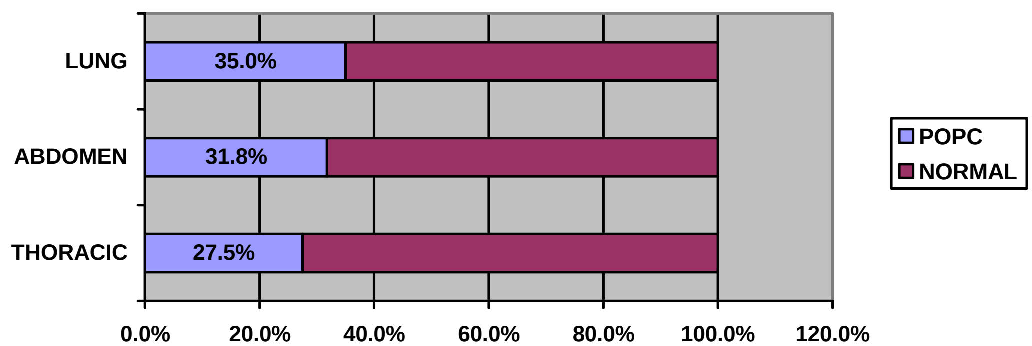

Fig 4. POPC in various surgeries

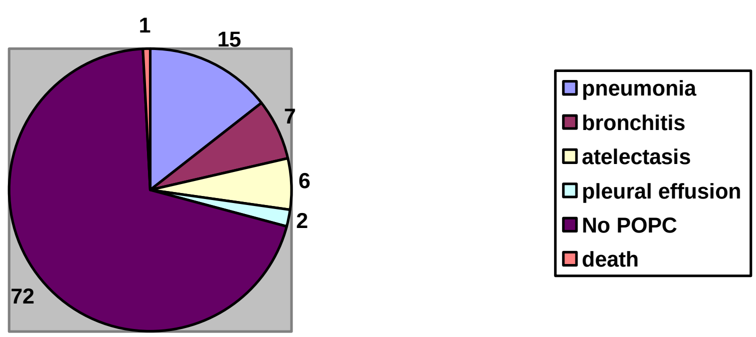

Fig 5. Post operative pulmonary complication

Table – 5 Clinical and laboratory characteristics of patients with and without postoperative pulmonary complication (POPC)

Characteristics	POPC (+) N= 30	POPC(-) N= 72	Number	P-value
Age <50	18 (26.4%)	50 (73.5%)	68	
>50	12 (35.3%)	22 (64.7%)	34	0.001
Male	21 (33.8%)	41 (66.1%)	62	Ns
Female	9 (22.5%)	31 (77.5%)	40	
Smoking				
Yes	12 (40%)	24 (33.3%)	36	Ns
No	18 (60%)	48 (66.6%)	66	
Male yes	18 (50.0%)	18 (50.0%)	36	
No	3 (11.0%)	23 (89.0%)	26	<0.05
BMI				
<25	21 (27.6%)	55 (72.3%)	76	Ns
>25	9 (34.6%)	17 (65.4%)	26	
>30	2 (50%)	2 (50%)	4	
Spirometry				
FVC	2.15 ± 0.77	2.20 ± 0.78		Ns
FVC%	69.93±22.97	71.53±20.81		Ns
FEV1	1.72 ± 0.60	1.88 ± 0.62		Ns
FEV1%	65 ±15.99	73.28±21.79		0.08
FEV1/FVC	80.70±12.49	86.39± 9.86		<0.05
PEF	4.00 ± 1.62	4.34 ± 1.72		Ns
PEF%	53.03±20.31	60.67±21.31		0.09
FEV1 < 1.25	6 (40%)	9 (60%)	15	
>1.25	24 (27.6%)	63 (72.4%)	87	Ns
Preoperative signs&symptoms				
Present	11 (31.4%)	24 (68.5%)	35	Ns
Absent	19 (28.3%)	48 (71.6%)	67	Ns
ASA				
<2	7 (21.2%)	26 (78.7%)	33	
>2	23 (33.3%)	46 (66.6%)	69	Ns
Thoracic surgery	16 (27.5%)	42 (72.4%)	58	
Abdomen surger	14 (31.8%)	30 (68.2%)	44	
Lung resection	5 (35.7%)	9 (67.3%)	14	
Comorbid				
Diabetes	16 (41.0%)	23 (59.0%)	39	
Hypertension	5 (31.2%)	11 (68.7%)	16	

Abnormal spirometry were noted with increase in age >50, BMI >25, and ASA > 2.Out of 30 POPC 25 had abnormal spirometry and rest 5 had normal spirometry see table 6.Microbiology of pneumonia is shown in (table-7).

Table – 6 Characteristics of patients with and without abnormal preoperative spirometry

Characteristics	Normal Spirometry N=29	Abnormal Spirometry n= (73)	number	P-value
Age <50 >50	 19 (28.0%) 10 (29.4%)	 49 (72.0%) 24 (70.6%)	 68 34	 <0.05
Male Female	19 (30.6%) 10 (25.0%)	43 (69.3%) 30 (75.0%)	62 40	 Ns
BMI <25 >25	 28 (36.8%) 1 (3.8%)	 48 (63.1%) 25 (96.1%)	 76 26	 <0.01
Smoking Yes No	 14 (38.9%) 15 (22.7%)	 22 (61.1%) 51 (77.3%)	 36 66	 0.08
Signs & symptoms Yes No	 10 (28.6%) 19 (33.3%)	 25 (71.4%) 48 (84.2%)	 35 57	 Ns
ASA <2 >2	 14 (42.4%) 15 (21.7%)	 19 (57.6%) 54 (78.3%)	 33 69	 <0.01
Complication Yes No Pneumonia Atelectasis Bronchitis Pleural effusion	 5 (16.7%) 24 (33.3%) 2 1 2 0	 25 (83.3%) 48 (66.7%) 13 6 4 2	 30 72	 0.08

No growth	6
Pseudomonas	5
Klebsiella	3
Coagulase negative staph.aureus	1

Table - 7 Pneumonia organisms

The sensitivity and specificity of some preoperative risk factors to predict postoperative pulmonary complications are shown in Table 8. Presence of abnormal findings in spirometry had higher sensitivity 83% and specificity 33% to predict complications than those of preoperative abnormal signs and symptoms.

Table – 8 the value of some preoperative assessments to predict postoperative pulmonary Complications

	Preoperative abnormal spirometry	Preoperative abnormal signs & symptoms
Sensitivity	83 %	68%
Specificity	33%	28%
False negative	16%	31%
False positive	67.7%	71%

DISCUSSION

General anaesthesia and surgical procedures affect the respiratory system negatively after upper abdominal and thoracic operations. Decreased diaphragm activity and ventilatory response causes decreased lung volumes. These may lead to alveolar collapse, atelectasis, early closing of airways, ventilation/perfusion imbalance, decrease in mucus clearance and increase in bacterial colonization. These changes may result in the development of serious pulmonary complications in patients with impaired pulmonary function (59).

In this study, POPC developed in 30 (29%) patients who underwent thoracic and upper abdominal surgery. POPC is highest in lung surgeries 5 (35%), followed by upper abdomen surgeries 14 (31.8%) and finally by thoracic surgery 16 (27.5%). Of 30 POPC pneumonia was 13, bronchitis 6, atelectasis 4 and pleural effusion 2 were observed.

In this study incidence of POPC was higher in patients with

1. Age >50 (35.3%) than age <50 (26.4%)
2. BMI >25 (34.6%) than BMI <25 (27.6%)
3. ASA >2 (33.3%) than ASA <2 (21.2%)
4. Smoking history
5. Diabetes mellitus
6. FEV 1/FVC <80
7. FEV 1 <1.25 (40%) than FEV 1 >1.25 (27.6%) and
8. Abnormal spirometry (83.3%) than normal spirometry (16.2%)

Stein et al. (5) published a prospective study and found that the incidence of pulmonary complications was higher in patients with abnormal preoperative spirometry (70%) than in patients with normal spirometry (3%).

Latimer et al. and Collins et al. found abnormal spirometry (FEV, and FVC) to be a good predictor of POPC after surgery (6).

Grover et al. reported an operative mortality of 11.7% for patients with an FEV, of less than 1.25 1 compared with 3.8% for those with an FEV, of greater than 1.25 1 in cardiac surgery practice (60).

Kroenka et al.(52) and **Fuso et al** (49) supports the concept that abnormal lung function may be associated with higher incidence of POPC .

In this study POPC is 30(29%) of which pneumonia 13, bronchitis 6, atelectasis 4, pleural effusion 2 were observed. **Arozullah, et al** developed postoperative pneumonia risk index that included type of surgery (abdominal aortic aneurysm repair, thoracic, upper abdominal, neck, vascular, and neurosurgery), age, functional status, weight loss, chronic obstructive pulmonary disease, general anesthesia, impaired sensorium, cerebral vascular accident, blood urea nitrogen level, transfusion, emergency surgery, long-term steroid use, smoking, and alcohol use. Patients were divided into five risk classes by using risk index scores. Pneumonia rates were 0.2% among those with 0 to 15 risk points, 1.2% for those with 16 to 25 risk points, 4.0% for those with 26 to 40 risk points, 9.4% for those with 41 to 55 risk points, and 15.3% for those with more than 55 risk points. The C-statistic was 0.805 for the development cohort and 0.817 for the validation cohort. He concluded that the postoperative pneumonia risk index identifies patients at risk for postoperative pneumonia and may be useful in guiding perioperative respiratory care (58).

In this study abnormal spirometry where noted in patients with age above 50, BMI above 25, smoking, ASA above 2. POPC were increased in patients with abnormal spirometry. Sensitivity of spirometry for detecting POPC is 83%.

Spirometry, which has been clinically available since the mid-1950s has been believed to satisfy the criteria of an ideal screening test, it is inexpensive, readily available, easy to apply, applicable to a larger number of patients, reproducible and has acceptable normal values (24). However, role of spirometry in predicting POPC has shown varying results in earlier studies. In this study, POPC developed more frequently in patients with abnormal preoperative spirometry.. Sensitivity and specificity of abnormal preoperative spirometry to predict POPC were higher than those of abnormal findings of physical examination. These findings indicate that spirometry may be an useful screening test to predict POPC risk.

Many studies suggest that there are multiple risk factors responsible for the development of POPC (advanced age, obesity, smoking, longer operation time, proximity of incision to diaphragm andpresence of lung pathology), so it is difficult to predict POPC based on spirometry alone (15). Results from this study agree with this thought. Findings from this study show that presence of abnormal preoperative spirometry, abnormal findings of physical examination, advanced age, smoking, higher ASA class, BMI >25, and diabetes mellitus are risk factors for pulmonary complications. We suggest that it would be useful to devise a new multifactorial risk index to detect patients at high risk of POPC.

We conclude that POPC after elective thoracic and upper abdominal surgery is still common (29%) and it is an important cause of postoperative morbidity. Multiple factors, which include abnormal preoperative spirometry, are responsible for the genesis of POPC. . Hence when spirometry used along with other parameters such as age, BMI, ASA, smoking history and comorbid conditions such as diabetes mellitus improves the prediction of POPC after thoracic and upper abdominal surgery.

CONCLUSION

The purpose of this study is to indentify the incidence and predisposing factors of post operative pulmonary complication (POPC) in government general hospital, Chennai. Previous studies have shown POPC varied between 5-70%, the highest rates were for upper abdominal and thoracic procedures. Despite many advances in medical and surgical practice, the incidence of POPC has not changed appreciably over the past 35 yr.

In our study POPC in thoracic surgery, lung resection and abdominal surgery is 27.5%, 35%, 31.5% respectively. The overall POPC is 29%. POPC increased with

1. age >50 (35.3%) than age <50 (26.4%)
2. BMI >25 (34.6%) than BMI <25 (27.6%)
3. ASA >2 (33.3%) than ASA <2 (21.2%)
4. Smoking history
5. Diabetes mellitus
6. FEV 1/FVC <80
7. FEV 1 <1.25 (40%) than FEV 1 >1.25 (27.6%) and
8. Abnormal spirometry (83.3%) than normal spirometry (16.2%).

We conclude that Multiple factors, which include age >50, BMI>25, higher ASA grade, smoking, diabetes mellitus and abnormal findings in preoperative spirometry, are responsible for the genesis of POPC. Hence when spirometry used along with other parameters such as age, BMI, ASA, smoking history and comorbid conditions such as diabetes mellitus improves the prediction of POPC after thoracic and upper abdominal surgery.

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ABBREVIATIONS

ASA	American Society of Anesthesiologists
ASD	Atrial septal defect
CABG	Coronary artery bypass graft
COPD	Chronic obstructive pulmonary disease
CV	Closing volume
DLCO	Diffusing lung capacity of carbon mono oxide
FEV1	Forced expiratory volume in one seconds
FRC	Functional residual capacity
FVC	Forced vital capacity
PDA	Patent ductus arteriosus
PEF	Peak expiratory flow
POPC	Post operative pulmonary complication
PPO	Predicted post operative
RHD	Rheumatic heart disease
V O2 Max	Volume of maximum oxygen consumption

MASTER CHART 1

Sr.No	Sex	Age	BMI	Smoking	Symptom	ASA	Comorbid	Spiro Inter	Complication
1	1	1	1	0	0	3	0	2	2
2	1	2	3	1	0	3	12	1	3
3	1	1	1	0	1	2	0	1	0
4	2	1	1	0	1	3	0	2	3
5	1	2	2	0	0	3	1	0	0
6	1	1	1	1	1	3	1	2	4
7	1	1	1	0	0	2	0	2	0
8	1	1	1	0	0	3	0	0	1
9	2	1	1	0	0	3	0	2	0
10	2	1	1	0	1	3	0	2	0
11	1	1	2	0	0	3	0	2	0
12	2	1	1	0	0	3	0	2	0
13	1	2	1	0	1	3	2	0	0
14	1	1	1	1	0	3	12	0	2
15	1	2	1	1	0	3	12	0	0
16	1	1	1	0	0	3	0	0	0
17	1	1	2	1	0	3	1	2	2
18	1	1	1	0	0	3	0	2	0
19	2	2	1	0	0	3	12	2	0
20	1	1	1	0	0	3	0	2	0
21	1	2	3	1	0	3	12	2	2
22	1	1	1	1	0	3	12	2	0
23	1	1	1	1	0	3	0	2	3
24	2	1	2	0	1	3	0	2	0
25	1	1	2	1	0	3	0	1	0
26	2	1	2	0	0	3	0	2	0
27	2	2	1	0	0	3	1	2	2
28	2	2	1	0	0	2	1	1	4
29	1	2	1	1	0	3	1	2	2
30	2	2	2	0	0	3	1	1	0
31	2	2	1	0	0	2	1	2	2
32	1	1	1	0	0	1	0	0	0
33	2	2	1	0	0	2	0	2	0
34	1	2	2	0	0	2	0	2	0
35	2	1	1	0	0	2	0	0	0
36	2	1	1	0	0	2	0	2	0
37	1	2	1	1	1	2	1	1	1
38	2	2	1	0	0	3	0	2	0
39	1	2	1	0	1	3	0	0	0
40	2	2	1	0	0	1	0	0	2
41	1	1	1	1	1	3	0	2	0
43	2	1	1	0	0	1	0	0	0
44	2	1	2	0	0	3	0	2	1
45	1	1	1	1	0	3	0	2	1

46	1	2	1	0	0	3	12	0	0
47	1	2	1	1	0	3	0	1	0
48	2	1	1	0	0	3	1	2	0
49	1	1	1	1	0	1	1	0	0
42	2	2	3	0	1	2	0	2	0
50	1	2	2	1	1	3	1	2	0
51	2	1	1	0	0	2	0	2	0
52	1	2	2	1	0	3	1	1	0
53	2	1	1	0	1	3	0	1	0
54	1	1	1	0	1	2	0	0	0
55	1	2	1	1	0	3	1	2	2
56	1	1	1	0	1	3	0	1	0
57	1	1	1	0	1	3	0	2	0
58	2	1	1	0	1	2	0	0	3
59	2	1	1	0	1	3	0	0	0
60	1	1	1	1	1	3	0	0	0
61	1	1	2	0	0	3	12	1	0
62	2	1	2	0	1	3	0	2	2
63	1	2	2	1	0	3	12	1	0
64	2	1	1	0	1	3	0	1	0
65	2	1	1	0	1	2	0	0	0
66	1	1	1	1	1	3	0	1	2
67	1	1	1	0	1	3	0	2	0
68	1	1	1	1	1	2	0	1	1
69	2	1	1	0	1	3	0	2	0
70	1	2	1	1	1	3	12	0	0
71	1	1	1	1	0	2	0	2	3
72	1	2	1	0	0	3	12	0	0
73	2	1	1	0	0	2	0	0	0
74	1	1	1	1	0	3	2	2	0
75	2	1	1	0	0	3	0	2	0
76	2	1	2	0	0	3	0	2	0
77	2	1	1	0	0	3	0	1	0
78	1	1	1	1	0	3	1	2	0
79	1	1	2	1	1	3	12	1	2
80	1	1	2	0	0	3	0	2	0
81	1	2	1	1	1	3	1	0	0
82	1	2	1	1	1	3	1	1	3
83	2	1	1	0	0	3	1	2	0
84	1	1	1	0	0	1	1	0	0
85	1	2	2	1	1	3	1	2	0
86	2	1	1	0	0	2	0	2	0
87	1	1	1	0	0	2	0	1	0
88	1	1	2	1	1	3	1	1	2
89	1	2	2	1	0	3	12	1	2
90	1	1	1	1	1	3	0	1	3
91	1	1	1	1	0	3	0	0	1
92	2	2	3	0	1	2	1	2	0
93	2	1	1	0	0	1	0	0	0
94	1	2	1	1	1	3	12	0	0

95	2	2	2	0	0	3	1	1	2
96	1	1	1	1	0	1	0	0	0
97	2	1	1	0	0	2	1	2	0
98	1	2	2	0	0	2	1	2	0
99	2	1	1	0	0	2	0	0	0
100	1	1	1	0	1	2	0	1	0
101	1	1	1	0	0	3	0	2	0
102	2	1	1	0	0	2	0	0	0

MASTER CHART 2

Sr.No	FEV1 value	FEV1 %	PEFR value	PEFR %	FVC value	FVC %	FEV1/FVC %
1	1.2	36	2.01	22	1.41	36	85
2	1.37	59	2.66	37	1.99	71	69
3	1.45	48	3.92	52	2.2	65	66
4	1.57	68	2.46	38	1.82	69	86
5	2.32	87	4.58	61	2.32	85	100
6	2.26	70	4.29	45	2.34	54	96
7	2.11	69	4.52	53	2.32	65	91
8	2.87	91	6.06	80	3.27	86	88
9	1.86	83	3.78	62	2.01	77	93
10	1.46	45	3.87	51	1.51	41	97
11	2.41	68	6.55	71	2.48	60	97
12	1.17	46	2.41	37	1.31	44	89
13	3.42	110	7.63	89	3.74	92	91
14	2.44	87	4.58	60	2.78	81	88
15	2.16	91	2.09	36	2.55	84	85
16	2.18	103	5.31	89	2.49	98	88
17	2.11	75	6.73	83	2.22	66	95
18	2.54	92	3.24	39	2.55	78	100
19	1.71	85	3.67	60	1.79	76	96
20	1.12	36	2.76	31	1.33	35	84
21	1.25	50	3.98	50	1.36	45	92
22	1.86	70	5.37	68	1.96	60	95
23	1.97	62	5.53	61	2.4	64	82
24	0.78	36	3.53	58	0.8	32	98
25	1.98	54	2.64	30	2.87	63	69
26	1.37	60	3.46	54	1.64	63	84
27	1.71	80	5.41	89	1.85	74	92
28	0.72	48	1.24	24	1.15	65	63
29	2.19	86	6.35	80	2.29	72	96
30	0.91	57	1.76	33	1.43	76	64
31	0.67	58	1.04	21	0.75	52	89
32	3.15	103	7.5	85	3.77	104	84
33	1.26	61	1.93	31	1.4	58	90
34	1.83	60	5.54	66	2.15	56	85
35	2.58	106	5.47	85	2.8	100	92
36	1.78	81	4.8	78	1.8	70	99
37	1.34	50	1.92	24	2.17	61	62
38	0.77	57	2.96	58	0.77	46	100
39	2.83	106	8.36	103	3.23	97	88
40	1.72	83	4.59	77	2	82	86
41	1.3	50	3.67	47	1.38	45	94
42	1.26	65	2.99	52	1.35	59	93
43	2.11	89	3.53	54	2.28	82	93
44	0.65	56	2.46	52	0.77	53	84

45	1.79	63	4.61	54	1.79	54	100
46	2.36	115	6.87	100	2.73	103	86
47	2.89	95	5.79	69	4.66	125	62
48	1.37	75	4.76	86	1.45	67	94
49	2.53	87	6.06	71	2.93	85	86
50	1.75	71	2.62	34	1.93	64	91
51	1.39	60	2.22	35	1.58	60	88
52	1.5	60	6.18	79	2.24	74	67
53	1.91	89	2.92	45	2.4	91	80
54	2.4	74	6.39	73	3.25	85	91
55	2.46	85	4.59	54	2.61	72	94
56	1.67	56	3.92	46	2.2	65	56
57	1.43	46	4.9	85	1.59	45	90
58	1.72	83	4.59	77	2	82	86
59	2.11	89	3.53	54	2.28	82	93
60	2.53	87	6.06	71	2.93	85	86
61	1.98	54	2.64	30	2.87	63	69
62	1.37	60	3.46	54	1.64	63	84
63	1.5	60	6.18	79	2.24	74	67
64	1.6	70	2.92	45	2.4	91	67
65	2.4	74	6.39	73	3.25	85	91
66	1.45	48	3.92	46	2.2	65	66
67	1.43	46	4.9	85	1.59	45	90
68	1.45	48	3.92	52	2.2	65	66
69	1.17	46	2.41	37	1.31	44	89
70	3.42	110	7.6	89	3.74	92	91
71	2.11	69	4.52	53	2.32	65	91
72	2.16	91	2.09	36	2.55	84	85
73	2.1	103	5.31	89	2.49	98	88
74	1.12	36	2.76	31	1.33	35	84
75	1.17	46	2.41	37	1.31	44	89
76	1.37	60	3.46	54	1.64	63	85
77	1.56	68	2.92	45	2.4	91	65
78	1.86	70	5.37	68	1.96	60	95
79	1.98	54	2.64	30	2.87	63	69
80	2.41	68	6.55	71	1.51	41	97
81	2.83	106	8.36	103	3.23	97	88
82	2.89	95	5.79	69	4.66	175	62
83	1.37	75	4.76	86	1.45	67	94
84	2.53	87	6.06	71	2.93	85	86
85	1.75	71	2.62	34	1.93	64	91
86	1.39	60	2.22	35	1.58	60	88
87	1.43	56	3.92	52	2.2	65	65
88	1.98	54	2.64	30	2.87	63	69
89	1.5	60	6.18	79	2.24	74	67
90	1.45	48	3.92	46	2.2	65	66
91	2.53	87	6.06	71	2.93	85	86
92	1.26	65	2.99	52	1.35	59	93
93	2.11	89	3.53	54	2.28	82	93
94	2.26	115	6.87	100	2.73	103	86

95	0.88	55	1.76	33	1.43	76	62
96	3.15	103	2.5	85	3.77	104	84
97	1.26	61	1.93	31	1.4	58	90
98	1.83	60	5.54	66	2.15	56	85
99	2.58	106	5.47	85	2.8	100	92
100	1.45	59	3.92	52	2.2	65	66
101	1.12	36	2.76	31	1.33	35	84
102	2.18	103	5.31	81	2.49	98	88

KEY TO MASTER CHART

SEX:

MALE	1
FEMALE	2

SMOKING:

YES	1
NO	0

SYMPTOMATICS:

YES	1
NO	0

ASA:

GRADE 1	1
GRADE 2	2
GRADE 3	3

COMORBID:

DIABETES	1
HYPERTENTION	2

SPIROMETRY INTERPRETATION:

NORMAL	0
OBSTRUCTIVE	1
RESTRICTIVE	2

COMPLICATION:

BRONCHITIS	1
PNEUMONIA	2
ATELECTASIS	3
EFFUSION	4

AGE:

BELOW 50	1
ABOVE 50	2

BMI:

BELOW 25	1
ABOVE 25	2
ABOVE 30	3